

Dr. Robert Fox of Idaho National Laboratory examining vials of nanoparticle solutions made by processing single-source precursors with supercritical fluids.



Precision Nanoparticles

Manufacturing transformative materials uniformly

Technological Marketing Summary

Nanoparticles — specks of matter thousands of times thinner than the width of a human hair — are showing tremendous potential in the development of new, transformative materials.

Just as a grain of salt has a higher percentage of its atoms on the surface than a block of salt, due to their relative sizes, nanoparticles are so small that most of their atoms reside on the surface. This means atomic surface interactions dominate their behavior, giving them remarkable properties. The high surface interactions make nanoparticles exceptional for transmitting energy, which can be used for applications such as making transistors faster and more efficient. Nanoparticles are also of interest for solar

energy applications, where varying sized particles could be layered, allowing energy movement from multiple wavelengths, improving viability and functionality.

The challenge with nanoparticles has been consistently creating them at prescribed specific and uniform sizes. A team of researchers from Idaho National Laboratory and Idaho State University were attempting to produce nanoparticles using the traditional method in which a supercritical fluid is used as a solvent to dissolve source material. The supercritical carbon dioxide failed to break down the organometallic material, instead producing a coagulated yellow “goo” in the reactor vessel, and the team assumed the experiment had failed. Then a member

examined the material under an electron microscope and discovered nanoparticles smaller and more uniform than anything they’d seen.

After deconstructing the process, researchers were able to duplicate and formalize the supercritical fluids-based technique, which can now produce affordable, uniform (± 0.2 nm) particles in a designated diameter and a wide range of sizes (less than 1 to 100 nm). The process does not require special handling such as cleanrooms and is extremely cost effective. For instance, a gram of copper indium disulfide nanoparticles — until now difficult to produce in quantity at consistently high quality — can be made for just dollars.

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The Energy of Innovation



Vials of nanoparticles that can be distributed in a spray to produce uniformity and consistency on surfaces and in materials.



and magnets, also as catalysts in the advanced manufacturing of platform chemicals.

The promise of this breakthrough technology was recognized in 2009 with an R&D 100 Award.

Technological Benefits

- Uniform, micro-engineered material for advanced manufacturing
- Environmentally friendly technology for production
- Lower energy manufacturing costs
- Reduced overall production costs

Potential applications

Pharmaceuticals, catalysts for advanced chemical manufacturing, high-efficiency nanoprocessors for electronics, next-generation photovoltaic energy cells

For more information

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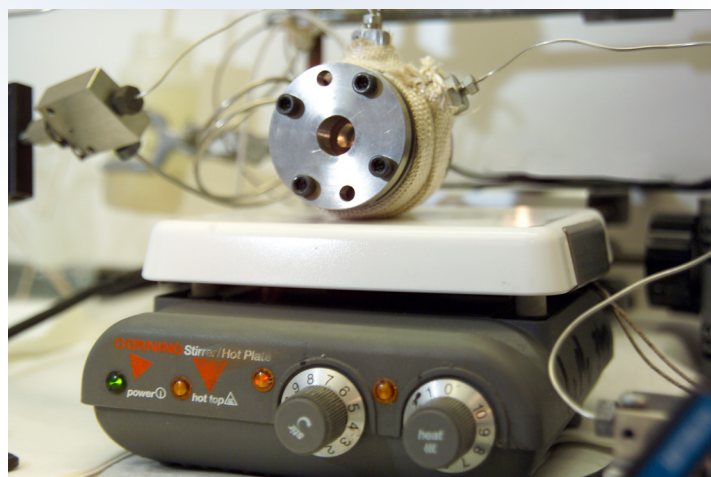


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Technology Description

Supercritical fluid extraction offers a more environmentally friendly, cost-competitive process for producing nanoparticles than traditional methods, which include attrition, pyrolysis and hydrothermal synthesis. A supercritical fluid is any substance at a temperature and pressure above its critical point, where distinct liquid and gas phases do not exist. Supercritical fluids can diffuse through solids like a gas, and dissolve materials like a liquid. By exposing single-source precursors — molecules containing elements connected by a single chemical bond — to carbon dioxide in a supercritical state, INL and ISU researchers have been able to form nanoparticles at set sizes. Instead of using high temperature, the process takes place at around 65 degrees Celsius, saving significant amounts

of energy. While the patented method using supercritical fluids were originally conceived as a process for making nanomaterials for cost-effective and high-efficiency photovoltaic cells, nanoparticles have also been recognized for their possibilities in pharmaceuticals, electronics



The laboratory apparatus used to generate nanoparticles by keeping carbon dioxide in a simultaneously liquid and gaseous state.

Additional Information

Additional information about Nanoparticles and supercritical fluid process can be found in U.S. Patent No 8,829,217 - "METHODS OF FORMING SINGLE SOURCE PRECURSORS, METHODS OF FORMING POLYMERIC SINGLE SOURCE PRECURSORS, AND SINGLE SOURCE PRECURSORS FORMED BY SUCH METHODS."